Pulmonary arterial lesions in new world camelids in association with dicrocoelium dendriticum and fasciola hepatica infection

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Abstract: In Switzerland, dicrocoeliasis is regarded as the most significant parasitic infection of llamas and alpacas. Fasciola hepatica infestation is also a problem but less common. The aim of the present retrospective study was to evaluate the lungs of New World camelids (NWCs) for evidence of arterial hypertension in association with liver changes due to liver fluke infestation. The lungs of 20 llamas and 20 alpacas with liver fluke infestation were histologically evaluated. The hematoxylin and eosin and van Gieson (VG)-elastica stains as well as immunohistology for the expression of -smooth muscle actin (-SMA) were used to visualize the structures of arterial walls. Parasitology of fecal matter (11 llamas and 17 alpacas) confirmed that most of these animals were infested with both Dicrocoelium dendriticum and other gastrointestinal parasites. In most cases (10/12 llamas, 4/6 alpacas), liver enzyme activity in serum was elevated. Histologically, arteries in the lungs of 9 of 20 llamas (45%) and 3 of 20 alpacas (15%) showed severe intimal and adventitial and slight to moderate medial thickening, which was confirmed with -SMA and VG-elastica staining. All animals exhibited typical liver changes, such as fibrosis and biliary hyperplasia, in association with the presence of liver flukes. This study shows that liver flukes can induce proliferative changes in lung arteries in NWCs that resemble those seen with pulmonary arterial hypertension due to liver parasites in humans. However, the degree of liver fluke infestation was not correlated with the extent of liver damage, or with the amount of thoracic or abdominal effusion or pulmonary arterial changes.

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Supplementary Table 2. Species, age, gender, occurrence and degree of thoracic and/or abdominal effusions, histological lung and liver changes as well as enzymes, liver fluke or egg occurrence in the liver in alpacas with liver fluke infestation

Species	**Age**	**Gender**	**Effusion**	**Lung vessels**	**Liver flukes/eggs Parasitology**	**Liver enzymes**	**Liver changes**
Alpaca	4 years	Female	Thoracic: + Abdominal: -	Intima: - Media: - Adventitia: -	- Parasitology: n.d.	n.d.	++-+++ Granulomas: - Abscesses: -
Alpaca (1)*	10 years	Female	Thoracic: - Abdominal: +++	Intima: - Media: - Adventitia: -	Dicrocoelium eggs in the biliary ducts Parasitology: Dicrocoelium +++	GGT and ASAT elevated. CK normal. SDH, GLDH, Albumin and AP n.d.	++ Granulomas: ++ Abscesses: -
Alpaca	2 years	Female	Thoracic: - Abdominal:	Intima: -	- Parasitology:	n.d.	+

			+++	Media: - Adventitia: -	Dicrocoelium +		Granulomas: - Abscesses: -
Alpaca	8 years	Female	Thoracic: - Abdominal: +	Intima: - Media: - Adventitia: -	- Parasitology: Dicrocoelium +	n.d.	+ Granulomas: - Abscesses: -
Alpaca	-	Female	Thoracic: - Abdominal: -	Intima: - Media: - Adventitia: -	Dicrocoelium flukes and eggs in the biliary ducts and in the parenchyma Parasitology: Dicrocoelium ++	n.d.	++-+++ Granulomas: - Abscesses: +
Alpaca	5 years	Female	Thoracic: + Abdominal: -	Intima: - Media: - Adventitia: -	Dicrocoelium flukes in the parenchyma Parasitology: n.d.	n.d.	+++ Granulomas: + Abscesses: +
Alpaca	7 years	Female	Thoracic: +++ Abdominal:	Intima: - Media: - Adventitia: -	Dicrocoelium eggs in the parenchyma Parasitology:	n.d.	++ Granulomas: + Abscesses: -

			+++		Dicrocoelium +-++		
Alpaca	3 years	Male	Thoracic: + Abdominal: +++	Intima: - Media: - Adventitia: -	- Parasitology: Dicrocoelium +-++	n.d	+-++ Granulomas: - Abscesses: -
Alpaca	8.5 months	Female	Thoracic: + Abdominal: -	Intima: - Media: - Adventitia: -	Dicrocoelium eggs in the parenchyma Parasitology: Dicrocoelium +-++	n.d.	+-++ Granulomas: - Abscesses: -
Alpaca (2)	7 years	Castrated male	Thoracic: - Abdominal: -	Intima: - Media: - Adventitia: -	Dicrocoelium flukes in the biliary ducts Parasitology: Dicrocoelium +-++	GGT, ASAT and CK elevated. SDH, GLDH, Albumin and AP n.d.	++ Granulomas: - Abscesses: -
Alpaca (3)	Adult	Male	Thoracic: - Abdominal: -	Intima: - Media: - Adventitia: -	Dicrocoelium eggs in the biliary ducts Parasitology:	GGT and ASAT elevated. CK normal.	+-++ Granulomas: - Abscesses: -

					Dicrocoelium +++	SDH, GLDH, Albumin and AP n.d.	
Alpaca (4)	4 years	Female	Thoracic: +++ Abdominal: +++	Intima: - Media: - Adventitia: -	Dicrocoelium eggs in the biliary ducts Parasitology: n.d.	GGT, SDH, CK, Albumin and AP elevated. ASAT normal. GLDH n.d.	++ Granulomas: - Abscesses: -
Alpaca	1.5 years	Male	Thoracic: - Abdominal: -	Intima: - Media: - Adventitia: -	Dicrocoelium eggs in the biliary ducts and liver flukes in the parenchyma Parasitology: Dicrocoelium +	n.d.	++ Granulomas: - Abscesses: +
Alpaca (5)	10 years	Male	Thoracic: - Abdominal:	Intima: -	- Parasitology:	SDH and ASAT	+

			-	Media: - Adventitia: -	Dicrocoelium +	elevated. GGT and Albumin normal. AP decreased. GLDH and CK n.d.	Granulomas: - Abscesses: -
Alpaca	5 years	Female	Thoracic: ++ Abdominal: +++	Intima: +++ Media: +-++ Adventitia: +++	Dicrocoelium flukes in the biliary ducts Parasitology: Dicrocoelium +	n.d.	++ Granulomas: + Abscesses: -
Alpaca (6)	5 years	Castrated male	Thoracic: - Abdominal: +++	Intima: - Media: - Adventitia: -	Dicrocoelium eggs in the parenchyma Parasitology: Dicrocoelium ++	GGT, SDH, ASAT, CK and AP elevated. Albumin decreased. GLDH n.d.	++-+++ Granulomas: + Abscesses: -
Alpaca	9.5	Female	Thoracic: +	Intima: -	-	n.d.	+-++

	months		Abdominal: -	Media: - Adventitia: -	Parasitology: Dicrocoelium ++		Granulomas: - Abscesses: -
Alpaca	-	Male	Thoracic: - Abdominal: +++	Intima: ++ Media: + Adventitia: ++-+++	Dicrocoelium eggs and flukes in the biliary ducts Parasitology: Dicrocoelium +++	n.d.	++ Granulomas: - Abscesses: -
Alpaca	4 years	Female	Thoracic: + Abdominal: +	Intima: ++ Media: +-++ Adventitia: +++	- Parasitology: Fasciola +	n.d.	++-+++ Granulomas: - Abscesses: +
Alpaca	8 years	Male	Thoracic: - Abdominal: -	Intima: - Media: - Adventitia: -	Fasciola flukes and eggs in the biliary ducts Parasitology: Fasciola ++	n.d.	+++ Granulomas: + Abscesses: +

Effusions (thoracic and/or abdominal): + = up to 1,5 liter; ++ = 2 to 3 liter; +++ more than 3 liter

Lung changes: Intima, media, adventitia: + = mild; ++ = moderate; +++ = strong; +-++ = mild to moderate; ++-+++ moderate to severe

Liver changes: median score between fibrosis, degeneration/regeneration, biliary proliferation, inflammation: + = mild; ++ = moderate; +++ = strong; +-++ = mild to moderate; ++-+++ moderate to severe

Granulomas: visible = + or not visible = -; abscesses: visible = + or not visible = -

Parasitology: Dicrocoelium: + = mild infestation; ++ = moderate infestation; +++ = strong infestation; negative = - n.d. = not done

Liver enzymes: GGT = Gamma Glutamyltransferase; SDH = Sorbitol Dehydrogenase; GLDH = Glutamate Dehydrogenase; ASAT = Aspartate Aminotransferase; CK = Creatine Kinase; AP = Alkaline Phosphatase

(1)* = number of the animal in table 3

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